WEAR-RESISTANT COMPOSITE RINGS FOR JEWELRY, MEDICAL OR INDUSTRIAL DEVICES AND MANUFACTURING METHOD THEREFOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to articles manufactured from sintered composite materials and methods for their manufacture. The sintered composite materials generally comprise, as the principal component, very hard powdered materials with high melting points, such as tungsten carbide, silicon carbide, aluminum oxide and ceramic materials, in combination with a much smaller amount of a softer binder metal, such as nickel, cobalt, palladium, platinum, ruthenium, iridium and gold, or alloys thereof, which has a lower melting point.

2. History of the Prior Art

For millennia, jewelry has been fabricated from soft metals, such as gold, silver and platinum, which are malleable, as well as castable and fusible at relatively low temperatures. Unfortunately, soft metals have very little resistance to abrasion. Thus, relief, detail and edges of soft metal jewelry tend to wear rapidly. This is particularly true if the jewelry is worn so that it comes in contact with hard objects and abrasive surfaces and particles.

Sintered, or cemented, composite materials comprising at least one metal carbide and a metallic binder have long been used for the manufacture of cutting tools as a result of their incredible hardness and durability. Such materials are made, using conventional well-known powder metallurgy, by bonding hard tungsten, tantalum, titanium, or chromium nitride particles with one or metals such as iron, cobalt, and nickel. The carbide particles, which are typically about 20-150μm in size, generally comprise between 75 and 85 percent, by weight of the cemented material. Nitrides and carbonitrides of the same metals may also be used as hard particles in cemented materials. Cemented materials may also be formed using a combination of two or more types of hard particles and binder metals such as ruthenium, rhodium, palladium, platinum, silver and gold.

A composite material is manufactured, for example, by mixing tungsten carbide

powder, tantalum carbide powder, cobalt powder and nickel powder according to a predertermined alloy composition, molding the material powder of mixed alloy composition by pressing the powder, and finally sintering the obtained molded pieces.

The major challenge of fabricating articles made of cemented metal carbides is that of finishing the raw sintered components. Because the molded pieces are formed using a high-pressure press, complex shapes may be impossible to fabricate and dimensional precision may be difficult or impossible to achieve directly. For example, products having shapes that can be formed in one axis direction only can be formed by die compaction. However, even if a cold isostatic press (CIP) technique is used to form three-dimensional shapes, high precision generally cannot be achieved because the items are molded inside rubber molds.

As a consequence of the need for more durable jewelry, jewelry manufacturers began fabricating watch cases and bands from cemented, or sintered, metal carbides, several decades ago. These early pieces were obtained using conventional processes, whereby relatively simple shapes formed by normal powder metallurgy methods were subjected to secondary machining, diamond grinding and electrical discharge operations to realize the complicated shapes required for watch cases and watch band pieces, which typically have curved surfaces, small holes and mirror-polished surfaces.

Accordingly, U.S. Pat. No. 5,403,374 discloses a process for manufacturing an exterior part for a watch having a three-dimensional curved surfaced and a small hole, without applying secondary machining operations.

The manufacturing of composite jewelry has expanded from watches to annular items. U.S. Pat. No. 6,062,045 discloses a finger ring having five facets having surface angles within a range of from 1 to 40 degrees. A related U.S. Pat., No. 6,553,667, discloses a system, apparatus and method for making composite jewelry items, such as finger rings, bracelets, earrings, body jewelry and the like. The focus of the patent is multiple methods of manufacture, the first of which includes the steps of preheating an annular substrate, contacting a depression in a surface of the substrate with a second material, heating the second material at a point contact with the substrate, causing the second material to liquify and flow into the depression, and moving the point of contact along the depression while continuously feeding the second material and heating the

second material at the point contact with the substrate to cause it to substantially fill the depression. The second method includes the steps of providing an annular composite article having an annular groove therein, forming a seamless ring from a metal wire that slides over the annular composite article, placing the annular composite article on a mandrel, and forcing the ring into the groove with a collet. The methods covered by this patent are costly and not particularly adapted to mass production.

What is needed is a simplified process for manufacturing finger rings, bracelets, earrings, body jewelry and the like, which are more suited to high volume low-cost production.

SUMMARY OF THE INVENTION

The present invention includes a method for manufacturing finger rings, bracelets, annular earrings, annular body jewelry and the like, which have at least one curved surface, from sintered, or cemented, composite materials comprising at least one metal carbide and a metallic binder. The annular jewelry piece may be inlaid with a precious metal and/or it may be subjected to a physical vapor deposition (PVD), chemical vapor deposition (CVD), or plasma chemical vapor deposition (PCVD) process in order to deposit thereon either a metal compound, such as titanium nitride, or a diamond-like carbon compound.

For all rings which are the subject of the present invention, the ring blanks are placed in a spinning fixture and subjected to abrasion against at least one curved abrasive surface. For comfort rings, the inner surface is formed as a continuous curve.

For rings having inlaid malleable precious metal, the precious metal is inserted in either a straight-wall, dovetail, or notched groove. The precious metal is inlaid in the groove by one of several processes, which may include hammering, rolling, or pressing. For embodiments of the process involving hammering and rolling of the inlay into the groove, the inlaying process may include the laser welding of joints and removal of any excess inlaid metal above the level of the mouth of the groove with a cutting tool affixed to a lathe in which the ring has been rotatably chucked. As an alternative to laser welding of the joint, the may be tack welded, torch welded, or soldered, or the precious metal may be burnished and subsequently cut back with a cutting tool. If the precious

metal is inlaid in a groove of either rectangular or dovetail cross section, a malleable precious metal wire of generally rectangular cross section may be used. For a dovetail or notched groove, it is necessary to deform the precious metal wire as it is hammered, rolled or pressed into the groove so that it expands to fill the slightly wider space below the mouth of the groove. For the straight-wall groove of rectangular cross section the wire may also be hammered, pressed or rolled in order to secure a tighter fit of the precious metal against the sidewalls of the groove.

The preferred method for inlaying a ductile metal in a groove involves the use of a press. The inlay band is formed as a ring either by laser welding the ends of a looped wire of rectangular cross section, or by stamping. The inlay ring is then pressed into the groove using a circular press. Any excess metal is then removed with a cutting tool in combination with a lathe.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an isometric view of a finger ring blank after a groove and facets have been ground on the outer surface and a comfort surface has been ground on the inner surface thereof;

Figure 2 is a cross-sectional view of the ring blank of Figure 1, taken through its axis of symmetry;

Figure 3 is a cross-sectional view of a ring blank similar to that of Figure 1, but having a dovetail groove therein;

Figure 4 is a cross-sectional view of a ring blank similar to that of Figure 1, but having a notched groove therein;

Figure 5 is an isometric view of a precious metal strip which has been formed into a hoop, but having a gap between the two ends thereof;

Figure 6 is an isometric view of the precious metal strip of Figure 5 following closing of the gap;

Figure 7 is an isometric view of the precious metal strip of Figure 6 following the laser welding of the abutting ends;

Figure 8 is an isometric view of the assembly comprising the ring blank of Figure 1 and the precious metal hoop of Figure 7, the latter having been slipped over the

former so that it is positioned above the groove of the blank;

Figure 9 is a front elevational view of the radial compression head of a hydraulic crimping and swaging machine, in which the ring and hoop have been positioned on a mandrel;

Figure 10 is a cross-sectional view of the assembly of Figure 8, but with the notched groove of Figure 4, taken through its axis of symmetry;

Figure 11 is a cross-sectional view of the assembly of Figure 10 following the compression of the hoop in the head of the crimping and swaging machine so that it is positioned within the groove of the ring blank;

Figure 12 is a cross-sectional view of the assembly of Figure 11 following further compression in the head of the crimping and swaging machine so that the hoop is squeezed into the notches of the groove of the ring blank;

Figure 13 is a side elevational view of a ring blank secured on the mandrel of a rolling machine, showing a precious metal strip being rolled into the groove in the ring blank;

Figure 14 is a side elevational view of a ring blank secured on the mandrel of a hammering machine, showing a precious metal strip being hammered into the groove in the ring blank;

Figure 15 is a cross-sectional view of a ring blank secured within a chuck and showing a process used to grind the comfort surface inside the ring blank;

Figure 16 is a cross sectional view of the ring blank of Figures 1 and 2 after its mounting on a mandrel and following the grinding of a notch in one sidewall of the groove thereof; and

Figure 17 is a cross-sectional view of the ring blank of Figure 16 following the grinding of a notch in the other sidewall of the groove thereof.

DETAILED DISCLOSURE OF THE INVENTION

The method for manufacturing finger rings, bracelets, annular earrings, annular body jewelry and the like from sintered, or cemented, composite materials comprising at least one metal carbide and a metallic binder will now be described in detail with reference to the attached drawing figures.

There are multiple aspects of the present invention. One involves forming at least one curved surface on the sintered composite material blank. Another involves the process of inlaying a precious metal in a groove in the sintered composite material blank using pressing, rolling or hammering. Still another involves subjecting the sintered composite material blank to a chemical vapor deposition process in order to deposit thereon a layer of nonallergenic material such as titanium nitride or diamond-like carbon. Yet another involves the grinding of notches in inlay grooves for improved anchoring of the precious metal inlay. These various aspects of the invention will now be described in detail with reference to the attaching drawing figures.

Referring now to Figure 1, an annular finger ring blank 100 made of sintered composite material has a pair of angled conical facets 102, an annular groove 103, and an interior comfort surface 101.

Referring now to Figure 2, the finger ring blank 100 is shown in a cross-sectional view, which shows the parallel, vertical walls 201 of annular groove 103 and the curved interior comfort surface 101.

Referring now to Figure 3, the finger ring blank 100 of Figures 1 and 2 has been modified so that the parallel, vertical walls 201 thereof have been replaced with slanted walls 302, which form a dovetail groove 301. The dovetail groove ensures that precious metal inlaid therein will be securely affixed to the ring. As a practical matter, it is very difficult to grind the slanted walls of a dovetail groove. Thus, the ring blank shown in Figure 4 is a more practical design.

Referring now to Figure 4, the finger ring blank 100 of Figures 1 and 2 has been modified so that the parallel, vertical walls 201 thereof have been replaced with notched vertical walls 402. The resulting groove 401 functions almost as well as, and is much more manufacturable than the dovetail groove 301. The method of forming the notched groove 401 will be subsequently disclosed.

Figures 5 through 12 depict the process used to form and press a precious metal hoop into the groove of a ring blank 300.

Referring now to Figure 5, a precious metal strip 501, which may be gold, silver, platinum or other precious ductile metal, has been formed into a hoop, but having a gap between the two ends 502A and 502B thereof.

Referring now to Figure 6, the gap between the two ends 502A and 502B of precious metal strip 501 has been closed in preparation for welding.

Referring now to Figure 7, the two ends 502A and 502B of precious metal strip 501 have been laser welded together to form an endless hoop 701. The laser welding step may be replaced with a tack welding, torch welding or soldering step. An endless hoop may also be produced in a number of other ways, which include stamping and casting.

Referring now to Figure 8, the precious metal hoop 701 of Figure 7 has been slipped over a sintered composite material ring blank 100, 200 or 300 so that the precious metal hoop 701 is positioned directly above the groove 103, 301 or 401, respectively.

Referring now to Figure 9, the assembly of Figure 8 is shown mounted on a mandrel 905 that is axially positioned within the head 901 of a Finn-Power crimping and swaging machine. The head 901 has eight radially movable collet members 902. The collet members are movable via hydraulic pressure applied to hydraulic fittings 903 via hydraulic lines 904. Although the machine was designed especially for crimping or swaging tubular collars used to secure fittings to the end of flexible lines and tubes, the machine can be used to compress or squeeze the precious metal hoop 701 into the groove of a ring blank 100 200 or 300.

Referring now to Figure 10, the assembly of Figure 8 is shown before the compression process is effected in the Finn-Power crimping and swaging machine.

Referring now to Figure 11, the precious metal hoop 701 has been compressed so that its diameter has shrunk to the extent that it is now annularly positioned within the groove 103, 301 or 401. As an example of a preferred embodiment of the invention, groove 401 is actually shown in this drawing figure.

Referring now to Figure 12, compression of the precious metal hoop 701 is continued until metal from the hoop 701 has squeezed into the notches of notched walls 402, thereby securing the metal hoop in the groove 300. Any excess inlaid metal above the level of the mouth of the groove may be removed with a cutting tool affixed to a lathe in which the ring has been rotatably chucked.

Referring now to Figure 13, a first alternative inlay method is shown, whereby a

precious metal strip 1302 is rolled into the groove 103, 301 or 401 of a ring blank 100, 200 or 300, respectively. The ring blank 100, 200 or 300 is positioned on a mandrel 1301 that is rotatable about a central axis 1304. As the ring blank 100, 200 or 300 is rotated on mandrel 1301, a roller 1303 pressed against the ring blank 100, 200 or 300 and forces the precious metal strip 302 into the groove 103, 301 or 401. The ends of the precious metal strip may be laser welded together or the precious metal strip 1302, once it is inlaid in the groove 103, 301 or 401, may be burnished in order to conceal the joint where the ends of the precious metal strip 302 meet.

Referring now to Figure 14, a is a second alternative inlay method is shown, whereby a precious metal strip 1302 is hammered into the groove 103, 301 or 401 of a ring blank 100, 200 or 300, respectively. The ring blank 100, 200 or 300 is positioned on a mandrel 1301 that is rotatable about a central axis 1304. As the ring blank 100, 200 or 300 is rotated on mandrel 1301, a reciprocating hammer head 1401 forces the precious metal strip 302 into the groove 103, 301 or 401. The ends of the precious metal strip may be laser welded together or the precious metal strip 1302, once it is inlaid in the groove 103, 301 or 401, may be burnished in order to conceal the joint where the ends of the precious metal strip 302 meet.

Referring now to Figure 15, a ring blank 300 is secured by jaws 1502 within a chuck 1501 that spins about a central axis 1503. A grinding wheel 1504 having a concave cross-sectional profile spins about an axis of symmetry 1505. The grind wheel 1504 grinds the comfort surface 101 in a grinding operation.

Referring now to Figures 16 and 17, the method of grinding the vertical sidewalls 201 of groove 103 (see Figure 2) to form a groove 401 having notched sidewalls 402 (see Figure 4) is shown. The ring blank 100 is secured on a mandrel 1601 that spins on a ring rotation axis 1602. A grinding wheel 1603 having diamond grit embedded therein is rotated on a grinding axis 1604 that makes an acute angle with and preferably intersects the ring rotation axis 1602. As shown in Figures 16 and 17, the notches may be cut one at a time by either reversing the ring for the second notch or in each wall 201 by simply reversing the ring by moving the tool to the other side.

Referring now to Figure 18, the notches in the sidewalls 201 of groove 103 may be ground simultaneously with the equipment set up as shown and employing two grind

wheels 1603A and 1603B.

Prior to the metal inlay process, the ring may be subjected to a physical vapor deposition (PVD), chemical vapor deposition (CVD), or plasma chemical vapor deposition (PCVD) process in order to deposit thereon either a metal compound, such as titanium nitride, or a diamond-like carbon compound. Titanium nitride is a gold coloured ceramic coating having a face-centered cubic crystal structure that is applied, most typically, by physical vapor deposition (PVD). Titanium nitride is characterized by extreme density, non-porosity, extreme hardness (approximately 85 Rc) that is greater than that of carbide compounds, and a low coefficient of friction. As it is a highly inert compound, it has excellent chemical resistance and hypoallergenicity. It is typically applied in thicknesses ranging from about 3 to 12 microns. Deposited titanium nitride films can be subjected to temperatures of up to 600 °C without damage, are highly conformal (i.e., the deposited film follows the contour of the substrate), able to withstand high temperatures, and form an outstanding bond to the substrate that will not blister, flake, or chip.

Titanium nitride coatings may be applied by PVD, CVD or PCVD. Each of these processes will be briefly addressed. Physical Vapor Deposition, or PVD, involves the atom-by-atom, molecule-by-molecule, or ion deposition of various materials on solid substrates in vacuum systems. Two types of physical vapor deposition are currently used. Thermal evaporation uses the atomic cloud formed by the evaporation of the coating material in a vacuum environment to coat all the surfaces in the line of sight between the substrate and the target (source). Sputtering, on the other hand, applies high-technology coatings such as ceramics, metal alloys, organic and inorganic compounds by connecting the workpiece and the substance to a high-voltage DC power supply in an argon vacuum system (10-2 - 10-3 mmHg). A plasma is established between the substrate (workpiece) and the target (donor) and transposes the sputtered off-target atoms to the surface of the substrate. When the substrate is non-conductive, radio-frequency (RF) sputtering is used.

Chemical Vapor Deposition, or CVD, is capable of producing thick, dense, ductile, and good adhesive coatings on metals and non-metals such as glass and plastic. Contrasting to the PVD coating in the "line of sight", the CVD can coat all

surfaces of the substrate.

Plasma-Assisted Chemical Vapor Deposition, or PCVD, is a technique for producing hard wear-resistant surface coatings on tools and wear parts. The difference between Plasma-Assisted CVD and conventional CVD lies mainly in a process temperature of about 500°C, as opposed to the 1000-1100°C temperatures of a conventional CVD process.

Diamond-like-carbon (DLC) is an amorphous coating with an extremely low coefficient of friction and extreme hardness. DLC coatings are typically applied by either CVD or PCVD processes. DLC CVD processes are generally limited to materials which will not soften at temperatures within a range of 700-750 °C. Cemented carbides certainly fall in this category. The PCVD DLC coating process can be performed at lower temperature than the DLC CVD processes.

As the patent and technical literature is replete with processes for PVD, CVD and PCVD for titanium nitride coatings, as well as processes for CVD and PCVD for diamond-like carbon coatings, no attempt will be made to provide detailed coverage, as the processes themselves are considered prior art. The inventive aspect is the coating of the cemented carbide ring blanks with those coatings in order to enhance their appearance, provide a more wear resistant surface, and render them hypoallergenic.

Although only several embodiments of the present invention have been disclosed herein, it will be obvious to those having ordinary skill in the art that changes and modifications may be made thereto without departing from the scope and spirit of the invention as hereinafter claimed.